Nov. 21, 1939. H. E. HOLLMANN 2,180,958

ELECTRONIC SYSTEM

Filed April 19, 1937

Fig. 1

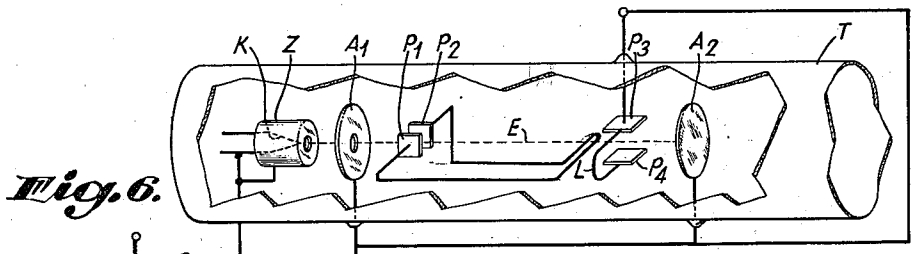
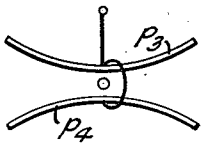


Fig. 6.



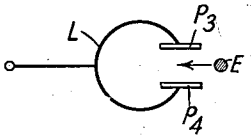


Fig. 2

Fig. 3

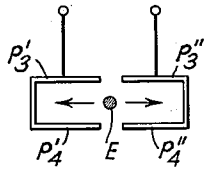


Fig. 5.

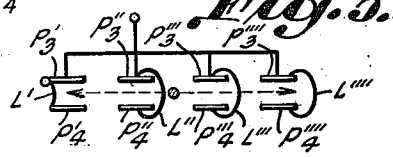


Fig. 4.

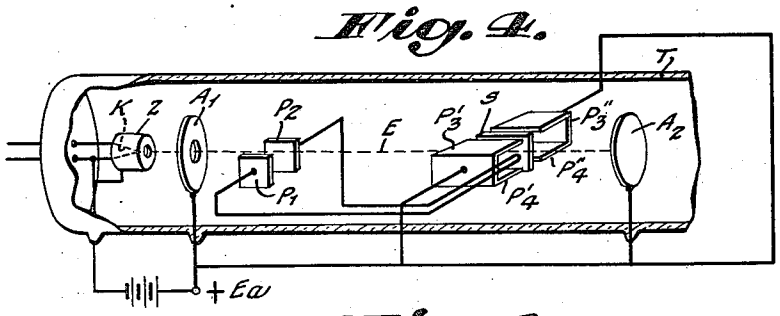
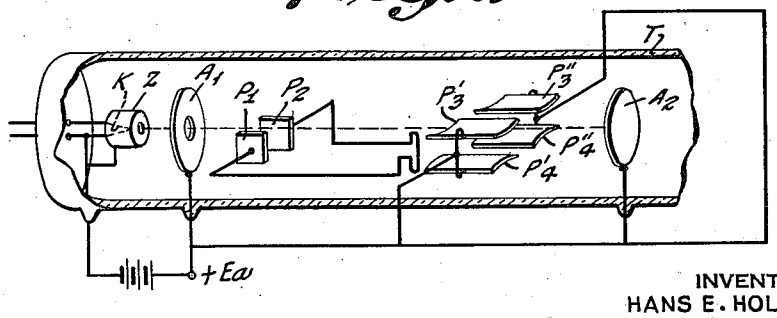


Fig. 7.



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ELECTRONIC SYSTEM

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Application April 19, 1937, Serial No. 137,689
In Germany April 14, 1936

3 Claims. (Cl. 250—36)

This invention relates to electronic devices and in particular, to amplifying and oscillatory electron tubes utilizing the cross-field principle of induced displacement currents.

The invention relates to a further development and a variation of the method and embodiment of the invention described in my copending application Serial No. 127,343, filed February 24, 1937 and entitled "Electronic systems" for amplifying and producing ultra-short waved oscillations according to the cross-control principle of displacement currents. The new and improved arrangement of my invention also works with a transversely-controlled cathode ray of any desired shape, e. g. thread-shaped, flat or disc-like. The difference between my present invention and that described in my copending application above identified lies in the fact that the energy of the transverse movement of the beam charges is not taken out in a cross field, whose field lines coincide with the deflection direction of the beam electrons, but by a hollow electrode through which the beam passes. If this hollow electrode is open on both sides, e. g. consists of two plates placed perpendicularly to the deflection plates and connected to one another, so that the beam in its transverse oscillations can leave the cross-control field laterally and again enter into same, then several cross-control fields can be arranged side by side, in contradistinction to the traversal limitations of the invention shown and described in my copending application above referred to.

In the above referred to copending application, I have described a new method of amplifying energy as well as producing oscillatory energy together with a description of apparatus for operating under the method of the invention therein disclosed. The method briefly is to project a beam of electrons between a pair of electrodes. The beam of electrons is then deflected laterally between the electrodes, and the displacement of the beam under deflection results in displacing a charge between a pair of electrodes, the electric charge being carried by the electrons. This moving charge induces between the electrodes a displacement current. I have called this the "cross-control" principle of operation. The displacement current flows through an oscillatory circuit which circuit in simple form is formed by an inductance loop connecting the electrodes between which the beam is deflected. By suitable geometry of the elements and control of the velocity of the beam of electrons, together with the deflection of the beam, the frequency of the displacement currents produced by the deflection can be made so that they are substantially equal to the natural frequency of the oscillatory circuit. The oscillatory circuit may then be coupled either to an output circuit for abstracting the energy produced by the displacement currents or the oscillatory energy may be fed back to a pair of deflecting electrodes in proper phase relation so that the produced displacement currents cause a deflection similar to the conventional form of regenerative control known to the art. It is to be noted in this respect that the important feature is the use of displacement currents, in contradistinction to the use of conduction currents for providing the amplification and oscillatory energy. As has already been pointed out in more detail in the above identified copending application, the use of displacement currents overcomes the limitations of the prior devices using conduction currents, because where displacement currents are used, there is no interruption of the beam of electrons, and accordingly, spaced charge effects need not be considered in the operation of the device. In contra-distinction to this, in conduction current devices, the electron beam is either interrupted or modulated, and hence, spaced charge effects vary in accordance with the variance of the density of the electron beam and these effects introduce frequency limitations in amplifiers and oscillators. The net result is that my present invention using displacement currents is capable of producing oscillations and amplifying signalling energy of much higher frequency and with much greater efficiency than was possible in devices using conduction currents.

In describing my invention in detail, reference will be made to the drawing, in which

Fig. 1 shows schematically one embodiment of my invention, showing the cross-field electrodes positioned at right angles to the deflecting electrodes;

Fig. 2 shows schematically an end view of the cross-field electrodes and the inductance loop;

Figs. 3 and 4 show modifications of the electrode structure shown in Fig. 2; while

Figs. 5, 6 and 7 show further modifications of the electrode structure shown in Fig. 2.

In order to describe more exactly the content and scope of the invention, there is shown in perspective view in Fig. 1 the fundamental arrangement of a cross-control tube embodying the idea of the invention. On the left, there is the system for producing the beam, consisting of the hot cathode K, the anode screen A_1 and the Wehnelt cylinder Z. The beam of electrons E issuing from this system or electron gun goes at first through

between the two deflection plates P_1 and P_2, to which there is applied the control potential to be amplified or obtained by reaction or feedback coupling. At a certain distance from this, upon which distance depends the amplification to be obtained based upon the geometrical increase of the oscillation amplitudes, there are arranged two plates P_3 and P_4, which are placed perpendicularly to the first deflection plates. After the beam of electrons has passed through the field between these plates, which are connected to one another by the inductance loop L, it is collected by the anode A_2. The cross-control system P_3—P_4 is connected to any desired useful load circuit, e. g. an oscillation circuit.

The effect of the cross-control process can be seen more clearly in Fig. 2, which shows a cross-section through the neutralizing plates P_3 and P_4 as well as through the electron beam E. As the drawn-in arrow shows, the oscillation movement of the electron beam is effected on the basis of the deflection by the control field P_1—P_2 in such a manner that the beam enters during the one half period into the cross-control field between P_3 and P_4 and leaves the same again during the next half-period. In the time during which the beam is between the plates P_3 and P_4 or, more exactly, while it is in the stray field already, charges are induced in the plates by influence, which can be conducted away to the outside as currents or potentials. During the rest of the time the cross-control field is free from charge.

In order to utilise the full influencing effect of the electron beam during the two half-periods, the arrangement shown in Fig. 3 which is identical with the structure shown in Fig. 4, except for the omission of the shield S can be used, which is composed of two cross-control fields namely in the first place the space between P_3' and P_4' and in the second place between P_3'' and P_4''. If the influence charges on P_3' and P_4' are for example negative, then the counter-field P_3''—P_4'' is free from charge. It is recognized therefore that the twe electrodes work in push-pull and are to be connected in a suitable manner to a useful resistance or they can be completed by an inductance loop or a parallel wire conductor to form an oscillation system.

In order to separate sharply from one another electrically the two push-pull cross-control fields, a metallic screen S in accordance with Fig. 4 can be inserted between the electrodes on both sides, which screen cuts the beam into two parts E' and E''. On the transverse deflection of the beam the one or the other part then preponderates, one of which with deflections greater than half the beam diameter disappears entirely. The effect of the charge influence in accordance with this invention is therefore not prejudiced in any way by the screen electrode S.

In Fig. 1 the undeflected beam passes through the middle of the area between the plates P_3 and P_4 and when deflected, it moves outside of this area twice, once to the right and once to the left, during each cycle of deflection. Thereby the influence charge disappears twice during each cycle, once each time the beam leaves the said area. In Fig. 2, however, the beam, when undeflected passes outside the said area and so there is only one disappearance of the influence charge per cycle. Thus, in Fig. 1 for each complete control period, two maxima and minima of the influence charges exist, i. e. the arrangement works as a frequency doubler.

As is known from the electron beam—frequency doublers or multipliers with collecting electrodes, high multiplying numbers are to be obtained, if instead of a single cross-control field several suitable electrodes are arranged beside each other. In Fig. 5 there are shown, for example, four of such cross-control fields in section, which provide an eight-fold multiplication of frequency since the pairs of plates P_3'—P_4' to P_3''''—P_4'''' are connected by inductance loops L' to L'''' and arranged in parallel. It will be appreciated, of course, that the electrode structure shown in Fig. 5 can be substituted for the electrode structure P_3 P_4 shown in Fig. 1 to provide this eight-fold multiplication of frequency. Instead of arranging the cross-control fields in a row side by side and to cause the electron beam to reverse at the ends of this row, it appears to be more suitable to arrange the coupling fields in a circular path, in which the electron beam is allowed to circulate, e. g., with the aid of two deflection fields perpendicular to one another and fed with 90° phase shift. This method offers the great advantage that the speed of circulation of the beam is everywhere constant, whereas with the flat arrangement in accordance with Fig. 5 the sine-shaped beam deflection speed must be compensated for by bringing the cross-control electrodes nearer to one another on both outer sides than at the centre. With the circular deflection on the other hand the fields can be evenly distributed over the circumference, as the beam moves with an even speed.

It is easy to be seen that the time curve of the potentials or currents influenced in all the arrangements shown in Figs. 1 to 5 will deviate very much from a sine-wave, because the influence charges only come into existence on the entry of the beam into the cross-control fields, and during the time in which the beam runs through the cross-control fields they remain constant, and only disappear again when the beam comes out. In certain cases the approximately rectangular curve shape which is caused by this may be suitable, e. g., when harmonics as high as possible are to be produced and then filtered out. If on the other hand the current or potential curve is to receive a sine shape, then the flat cross-control electrodes only need to be replaced by curved plates, as shown in Fig. 6. Since the strength of the influence charges depends, as is known, according to a quadratic law upon the distance, the influence effect gradually decreases the further the beam is deflected out of the centre. In connection with the sine-shaped beam oscillations, a sine-shaped curve of the influence current can, on the basis of this reduction law, be easily obtained as can any other desired curve shape.

In order also to carry this idea over to the push-pull arrangements shown in Figs. 3 and 4, one can proceed in such a way as either to split the plates in the middle according to Fig. 6 which electrode structure can be substituted for the electrode structure P_3 P_4 shown in Fig. 1, or the two push-pull systems can be built up in accordance with Fig. 7. For the purpose of oscillation production, in the simplest way, the cross-control plate pairs P_3' and P_4' as well as P_3'' and P_4'' are reaction-coupled galvanically, inductively or capacitatively to the deflection plates P_1 and P_2, whereby the internal phase conditions in the tube are to be made suitable for the coupling conditions of the external circuit by controlling the times of transit of the electrons, as is more

fully described in my above identified copending application. Amplitude modulation of such a reaction-coupled transmitter can be easily effected by influencing the beam current intensity after the manner of the known brightness modulation of television tubes.

The length of the cross-control plates in the direction of the electron beam is in the main subject to the same laws as are known for the control field from oscillograph technique with very high frequencies. However, the principle of the invention is not at all altered, if instead of one or several cross-control fields in the direction of the beam two or more rows of such fields are arranged in series, whose separate electrodes can be connected to one another in the same sense or connected together cross-wise. As such arrangements have already been proposed in othe places, it is not necessary to go further into them here.

I claim:

1. In a cathode ray tube wherein is provided means to produce an electron beam, an anode, a pair of opposed electrodes between said beam producing means and anode, and a single inductance loop only connecting said opposed electrodes, the method of producing oscillations which comprises the steps of projecting an electron beam from said beam producing means onto said anode, deflecting said beam between said electrodes with sufficient amplitude to pass the beam beyond the ends thereof to thereby produce currents by induced charges on said electrodes, and feeding back a portion of said produced currents from said one inductance loop to further deflect said beam.

2. Means for producing oscillations comprising a cathode ray tube comprising means for producing an electron beam, an anode for receiving said beam, a pair of opposed electrodes between said beam producing means and said anode, means for deflecting said beam in a plane between said electrodes with an amplitude sufficient to pass the beam beyond the ends thereof to produce currents by induced charges on said electrodes, a single inductive loop only connecting said opposed electrodes, and means for feeding back a portion of said produced currents from said one inductance loop to said deflecting means to further deflect said beam.

3. An electronic oscillator comprising an electron gun for producing a beam of electrons, an anode for receiving the produced beam, a plurality of pairs of opposed electrodes having spaces between said opposed electrodes, said spaces being in alignment with each other along a direction perpendicular to the axis of said electron gun and positioned intermediate said beam producing means and said anode, means to deflect the produced beam in a plane located between the opposed electrodes, and feedback connections from said plurality of opposed electrodes to said deflecting means for further deflecting the produced beam.

HANS E. HOLLMANN.